Jet Propulsion Laboratory
California Institute of Technology

Titan (Lake) Lander Studies

John Elliott
Jet Propulsion Laboratory
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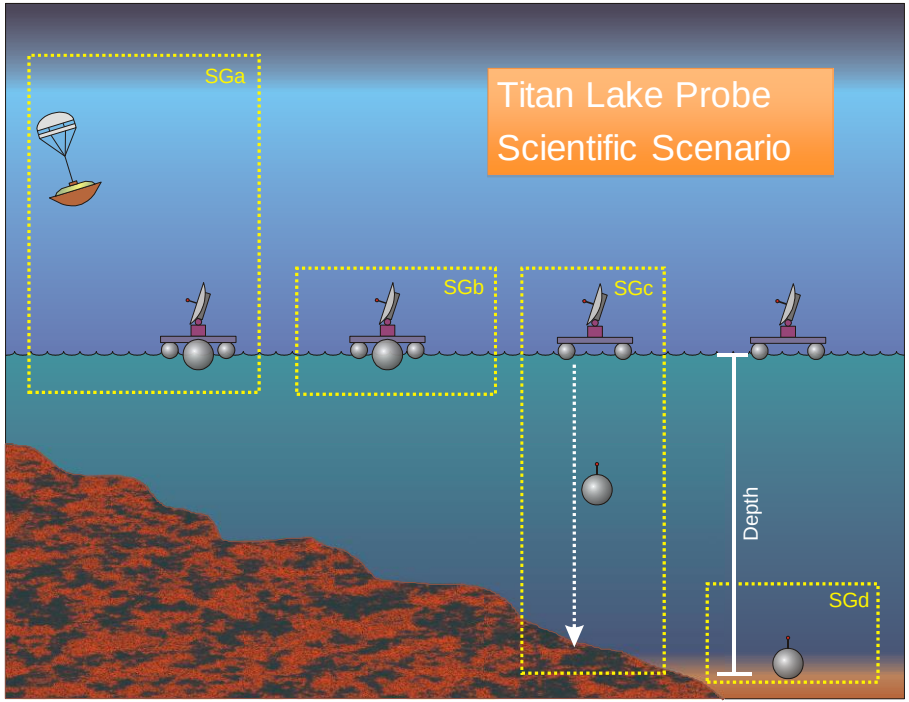
2010 – Decadal Survey Studies

- Decadal Survey studied mission concepts for surface and subsurface exploration of Titan lakes
- Four options studied, with decreasing levels of complexity to investigate missions with a range of costs

General Mission Concept Overview



SGa: To understand the formation and evolution of Titan and its atmosphere

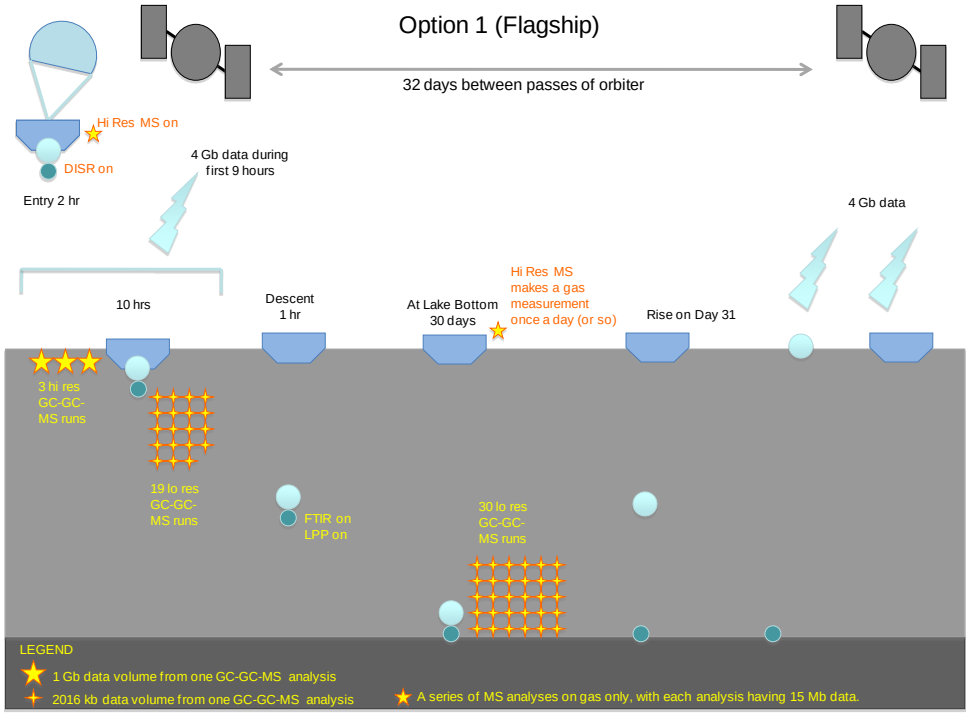
SGb: To study the lake-atmosphere interaction in order to determine the role of Titan's lakes in the methane cycle

SGc: To study the target lake as a laboratory for pre-biotic organic chemistry in both water (or NH3 enriched water) solutions and non-water solvents

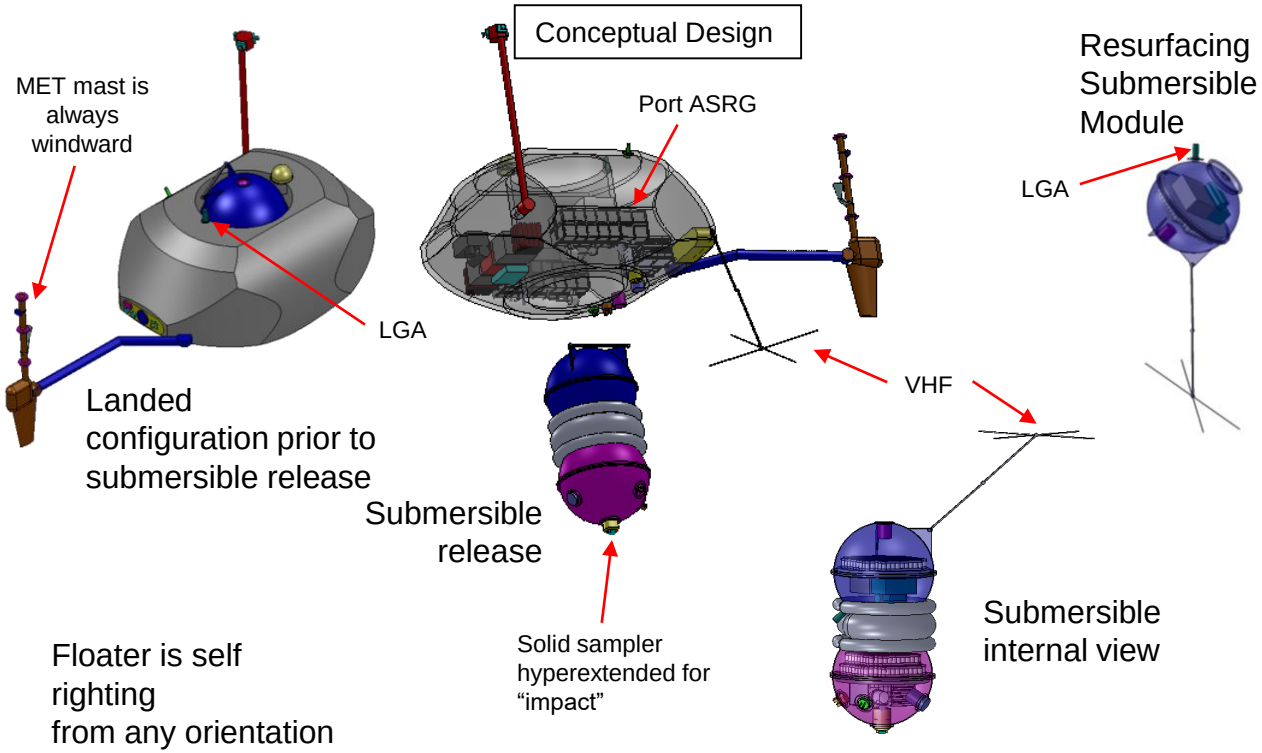
SGd: To understand if Titan has an interior ocean

Option 1 Overview

- Aimed at a flagship-class mission concept
- In-situ elements assumed to be delivered by Orbiter from Saturn orbit
- Design addressed all four areas of scientific interest
  - Atmospheric evolution
  - Atmosphere-lake interaction
  - Lake chemistry
  - Interior structure
- Reaches Kraken Mare after sunset – must relay data through spacecraft in Saturn orbit
- 2 ASRGs on the floater

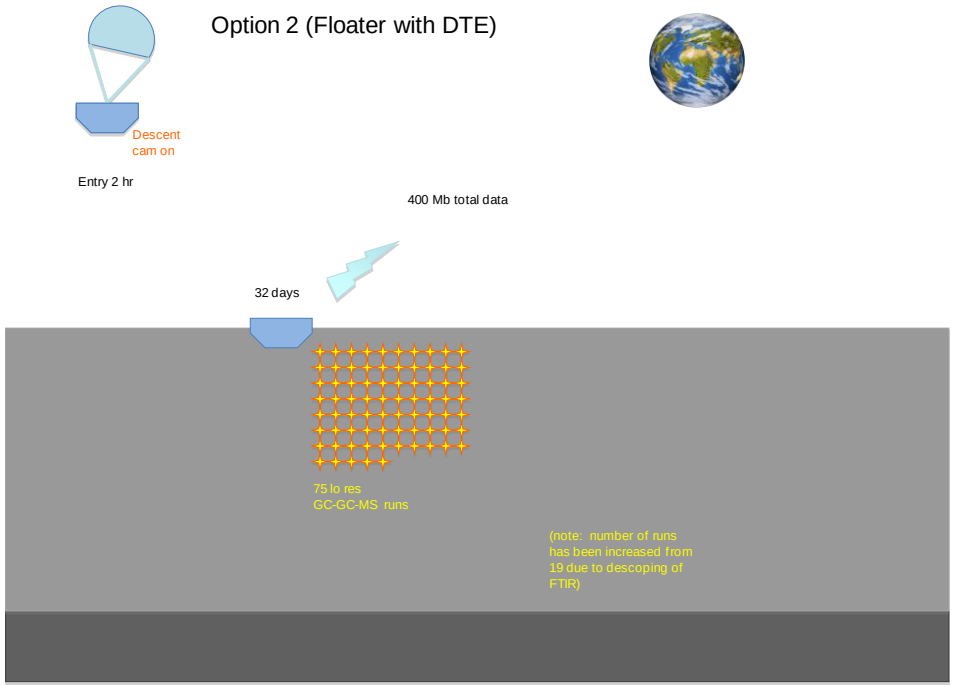


Option 1 Configuration



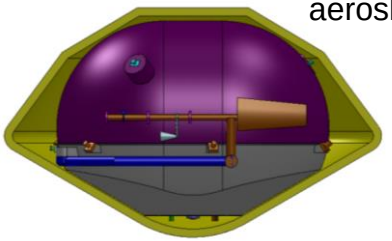
Option 2 Overview

- Aimed at a New Frontiers sized mission concept
- Design addressed three of four areas of scientific interest
  - Atmospheric evolution
  - Atmosphere-lake interaction
  - Lake chemistry
- Reaches Kraken Mare before sunset to enable DTE com
  - Required a bi-prop system and over 2000 kg of fuel
  - 6 year cruise
- Two ASRGs on the floater
  - Also provide power to carrier during cruise
- Requires X-Band DTE link due to Titan atmospheric attenuation
- Requires Atlas 551 or equivalent

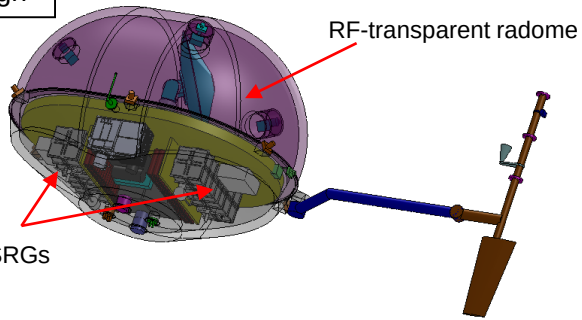


Option 2 - Surface Configuration

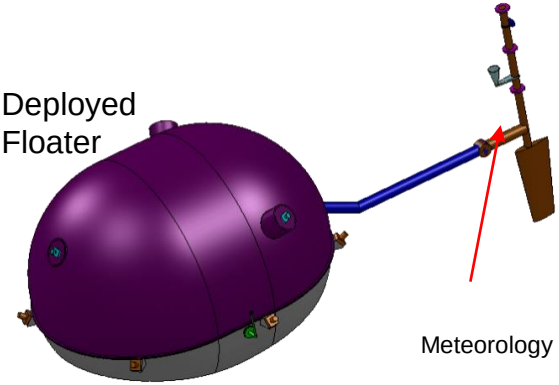
Stowed configuration in aeroshell

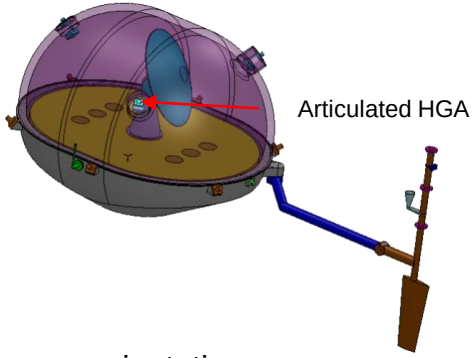


Conceptual Design



Deployed Floater

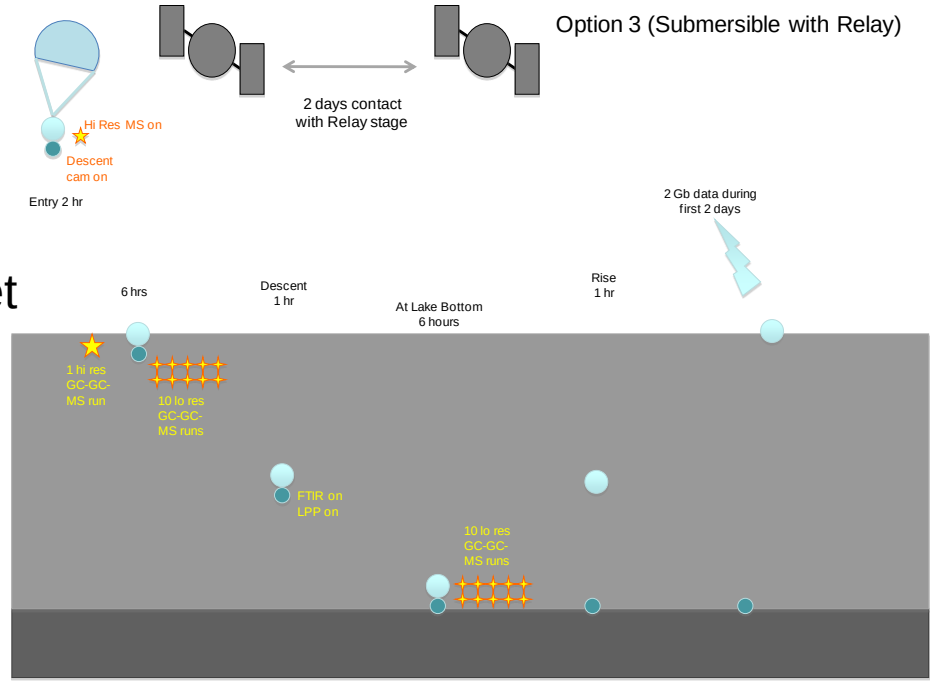




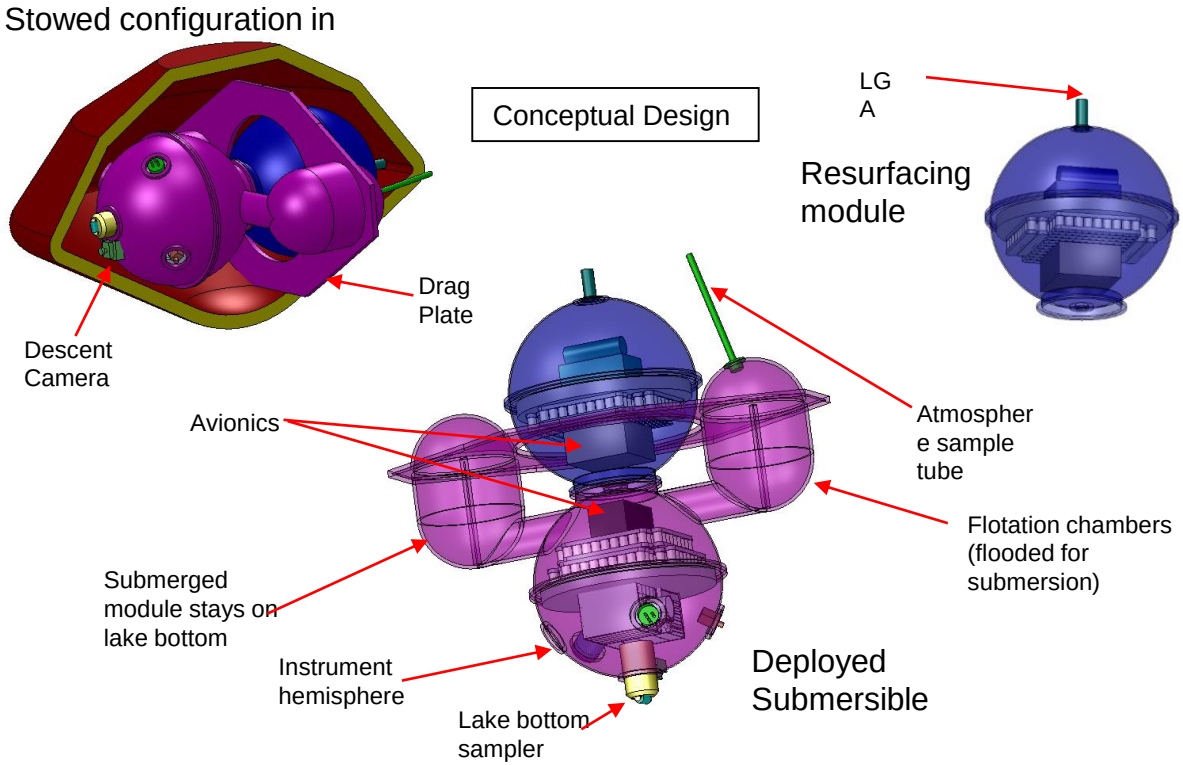
Floater is self righting from any orientation

Option 3 Overview

- Aimed at a New Frontiers sized mission concept
- Design addressed two of four areas of scientific interest
  - Atmospheric evolution
  - Lake chemistry
- Reaches Kraken Mare after sunset – data relay is required
  - Over 9 year cruise
- Two ASRGs on the relay spacecraft
- Requires an Atlas 401 or equivalent

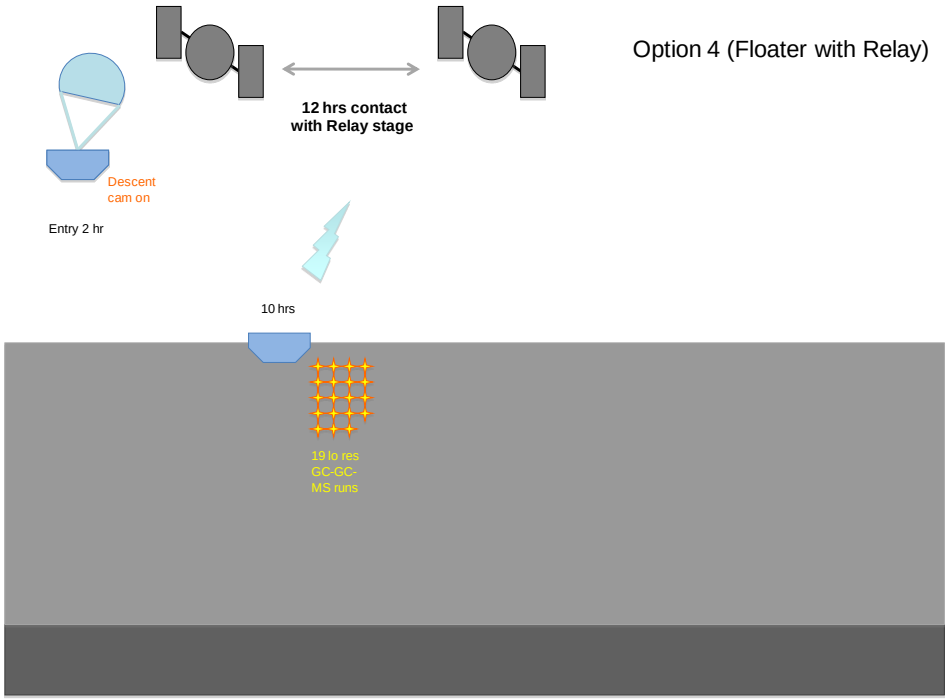


Option 3 - Surface Configuration



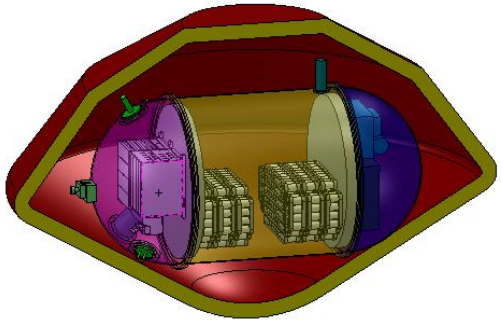
Option 4 Overview

- Aimed at a New Frontiers sized mission concept
- Design addressed two of four areas of scientific interest
  - Atmospheric evolution
  - Lake chemistry
- Reaches Kraken Mare after sunset – data relay is required
  - Over 9 year cruise
- Two ASRGs on the relay spacecraft
- Requires an Atlas 401 or equivalent

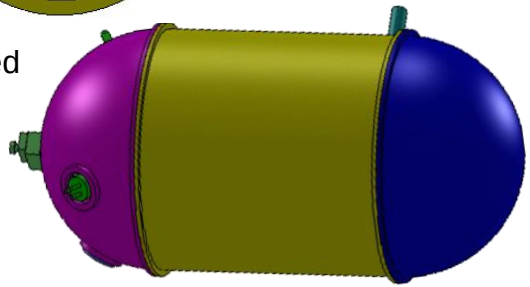


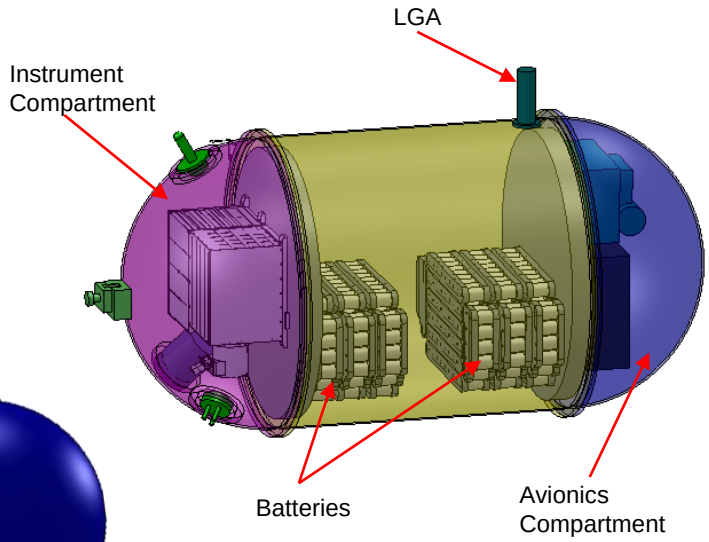
Option 4 - Surface Configuration

Stowed configuration in aeroshell



Deployed Floater





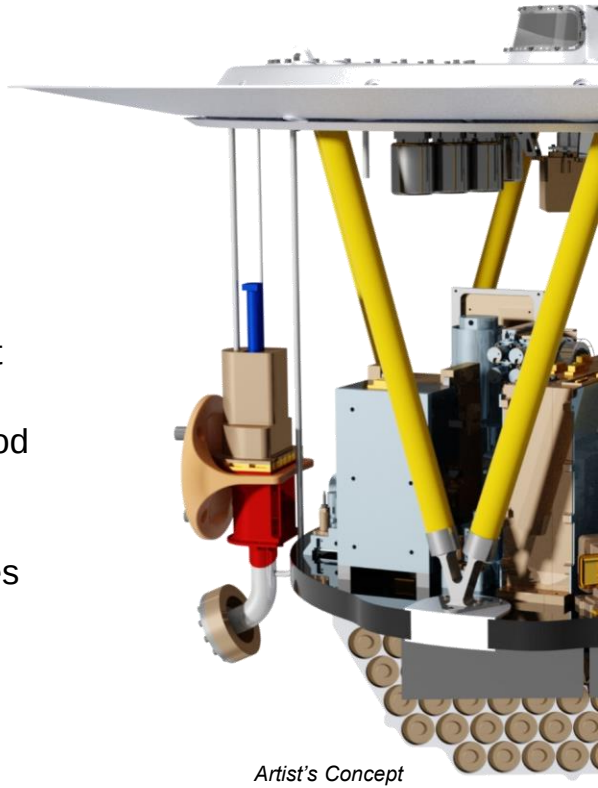
Conceptual Design

2016 New Frontiers Study

- Oceanus proposal to NF developed concept for battery powered sea probe that would operate with flyby orbiter/relay
  - Similar to Option 4 of Decadal study

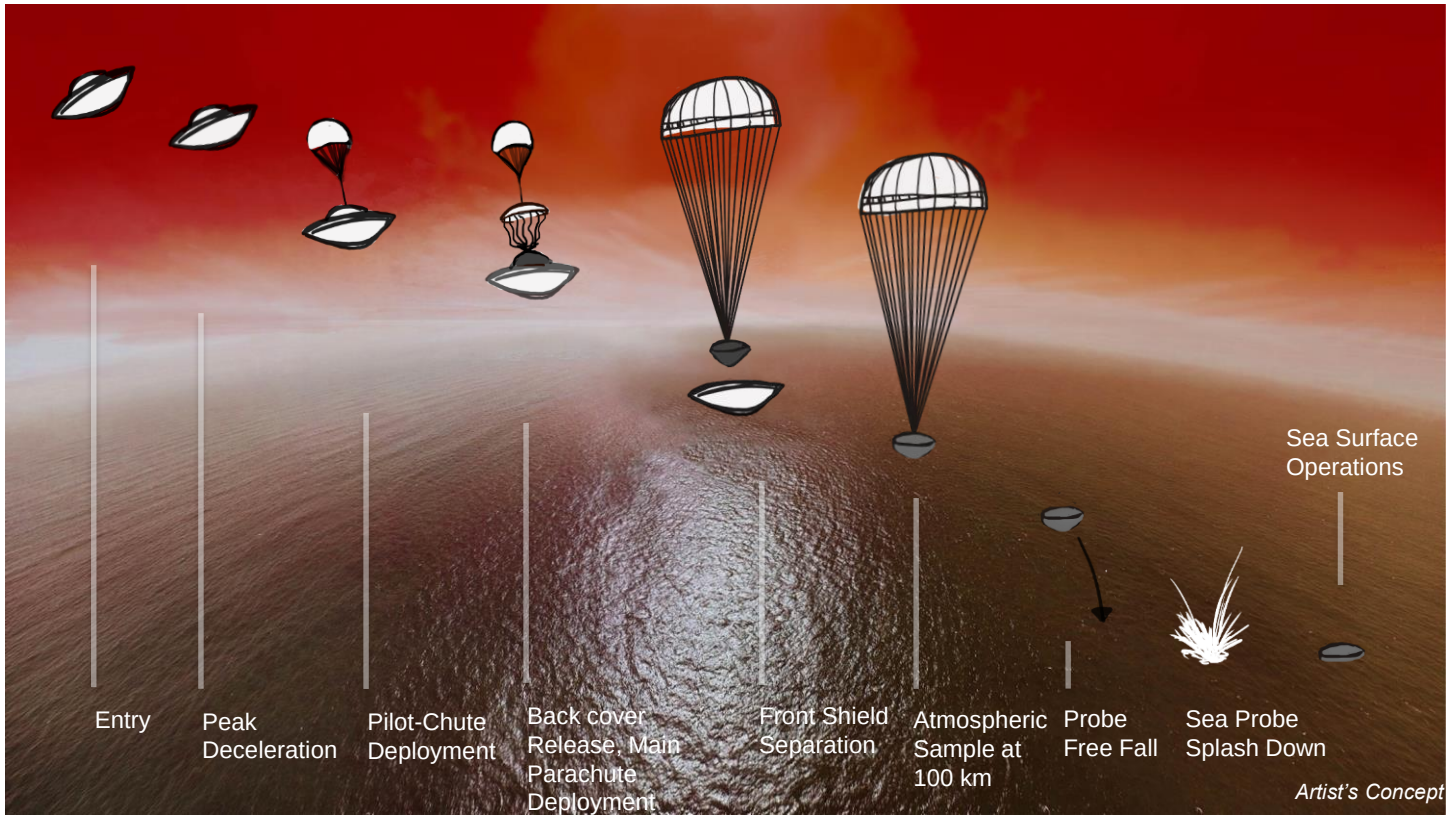
Probe Architecture Drivers

- Low mass/cost
  - Mass impacts orbiter design, impacts cost modeling
  - Ease of assembly and test
- EDL
  - Requirement to take upper atmosphere measurement at ~100 km
  - Need to minimize descent time to maximize time in sea
  - Minimize landing ellipse to safely fit in Kraken Mare
  - Splashdown load should be <20 g for mass spectrometer instrument
- Thermal
  - Need to minimize need for survival heating during 30 day coast period
  - Heat leak to the sea must be minimized (goal of <100 W/m2)
- Surface stability
  - Probe must be buoyant and stable for range of possible sea densities (500-630 g/cm3)
- Integration
  - Accommodate sample inlets for atmosphere and lake
  - Accommodate camera for descent and context imaging

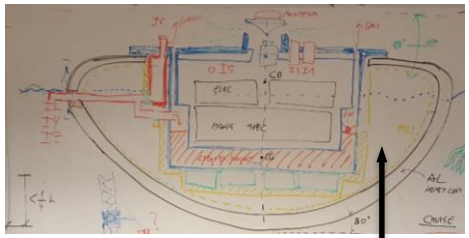


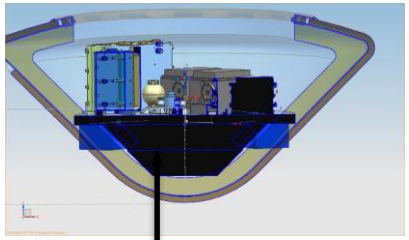
Artist's Concept

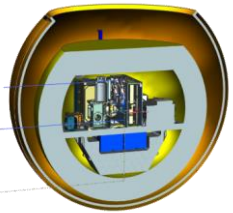
Notional EDL Sequence

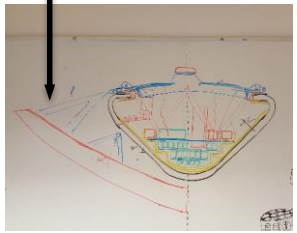


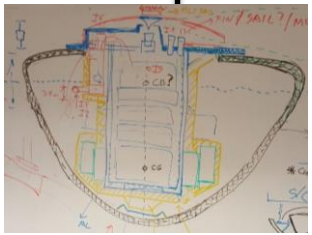
Architecture Evolution

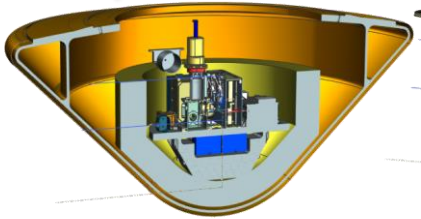


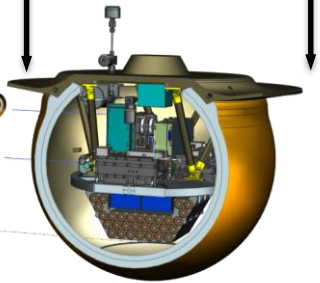


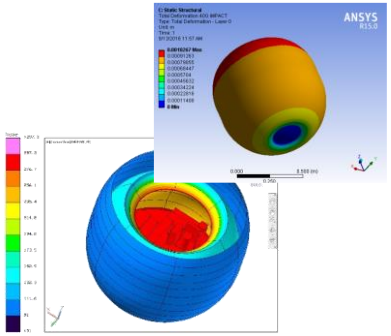




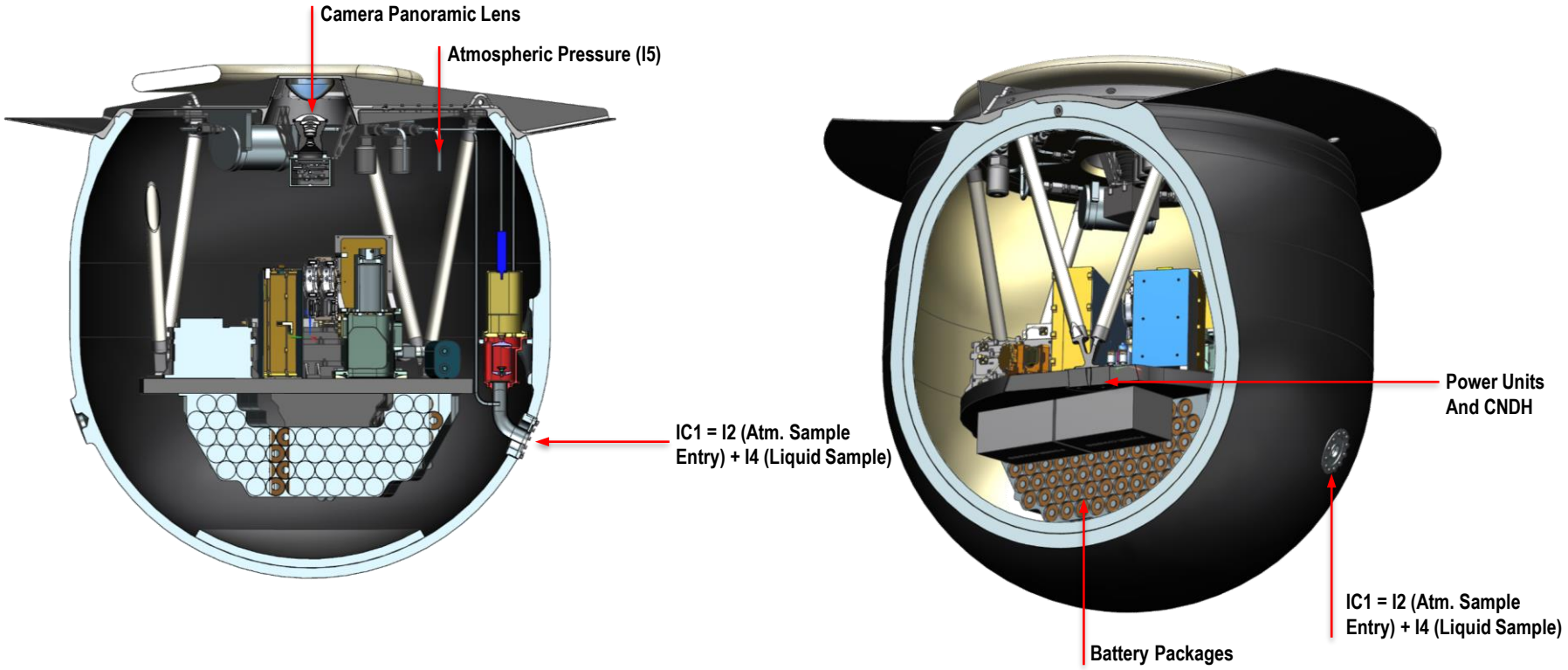




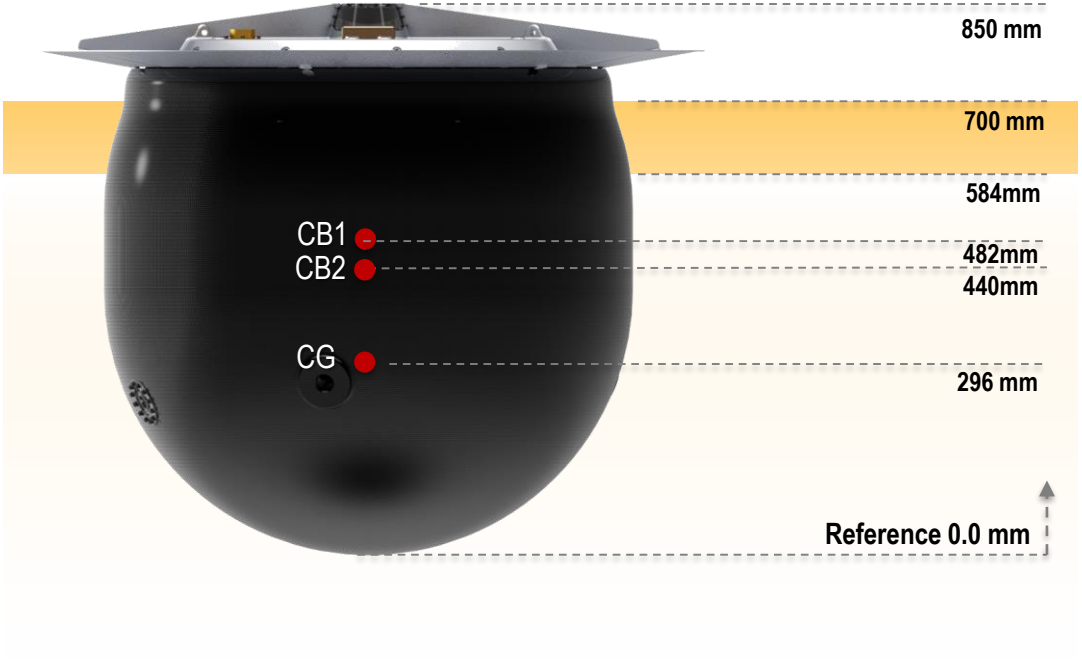




Proposed Internal Configuration



Buoyancy

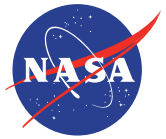


Float Level, minimum sea density (500 kg/m^3)

Float Level, maximum sea density (630 kg/m^3)

Technologies

- Studies made maximum use of existing technologies
- Areas identified as needing development
  - Liquid sampling system for lake (floater)
  - Solid sampling system for lake bed (submersible)
- Further areas that would enhance mission feasibility
  - Low temperature electronics
  - Low temperature batteries
  - Miniaturized avionics
  - Miniaturized instruments



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